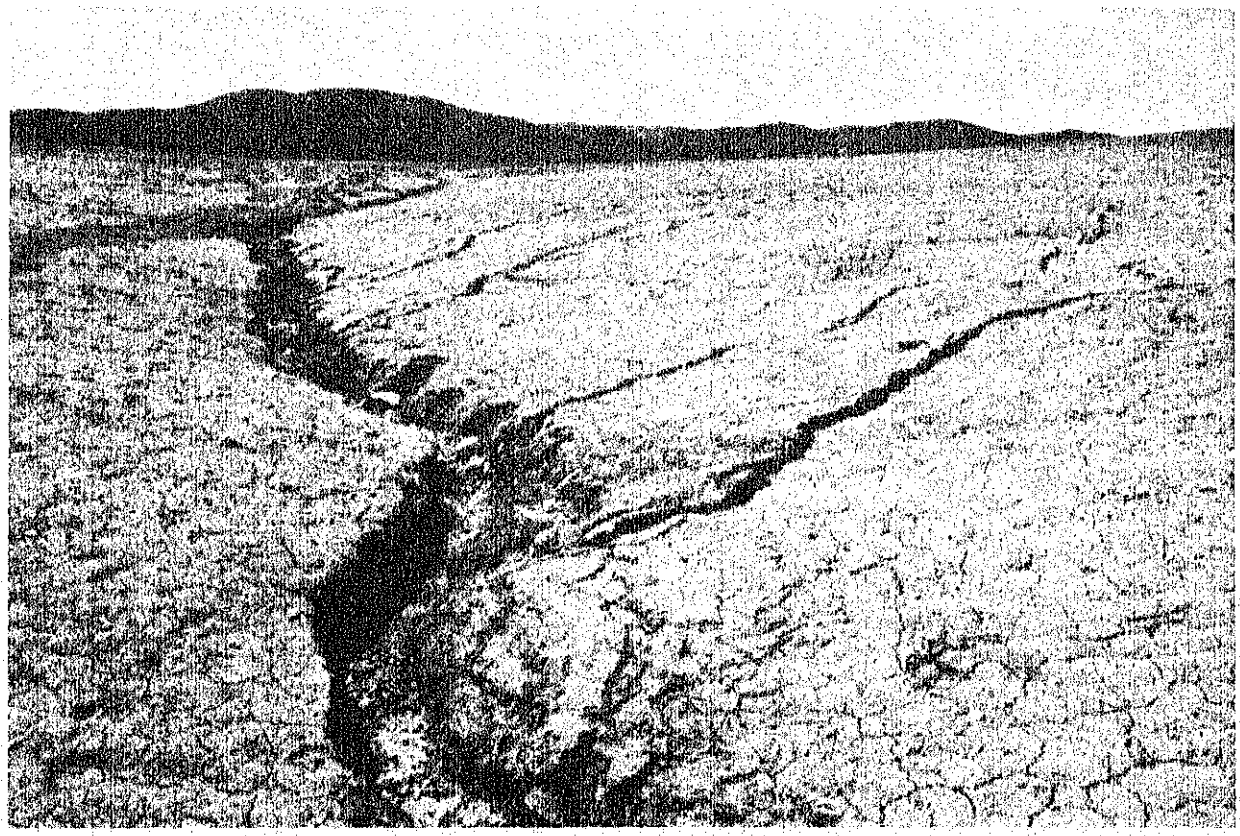
United States
Department of
Agriculture

Soil
Conservation
Service

Lakewood
Colorado

STATE OF COLORADO
YAMPA RIVER BASIN
RILL AND EPHEMERAL GULLY EROSION STUDY



JULY 1990

State of Colorado
Yampa River Basin Study

Rill and Ephemeral Gully Erosion From Snowmelt In Northwestern Colorado

Prepared by the
U.S. Department of Agriculture
Soil Conservation Service

July 1990

PREFACE

This report includes information on rill and ephemeral gully erosion from snowmelt on winter wheat fields in Northwestern Colorado.

The Universal Soil Loss Equation (USLE) has not treated snowmelt erosion adequately in the past. Information developed herein will help to illustrate the magnitude of this component of erosion. Some analyses of certain USLE factors were made. The snowmelt process was studied to some extent however a direct relationship to the erosion process was not made.

Ephemeral gully erosion measurements were taken and tested against the Ephemeral Gully Erosion Model (EGEM). The magnitude of this component of erosion is also illustrated.

Some observations of the erosion problem as it relates to minimum tillage and farming operations were made. Treatment opportunities along with conclusions and recommendations are discussed.

Photographs of high erosion sites are included to illustrate the magnitude of the problem. They can also be used as references for future estimates.

TABLE OF CONTENTS

Page

INTRODUCTION----------1

Objectives----------1
Authority----------1

STUDY AREA----------2

Climate----------2
Field Characteristics----------3

INVESTIGATIONS AND ANALYSIS----------5

Snowmelt Considerations----------5
Frost Considerations----------5
Rill Erosion Evaluations----------7
Ephemeral Gully Erosion Evaluations----------13
Economics of Erosion----------17

TREATMENT OPPORTUNITIES----------19

Minimum Tillage----------19
Farming Operations----------19
Other----------20

CONCLUSIONS AND RECOMENDATIONS----------21

REFRENCES----------24

PHOTOGRAPHS----------25-34

INTRODUCTION

This report was prepared by the U.S. Department of Agriculture, Soil Conservation Service, in an effort to evaluate rill and ephemeral gully erosion, from snowmelt, occurring on winter wheat fields in Northwestern Colorado. It presents results of field measurements, calculations, photographs of land conditions, and conclusions and recommendations.

Objectives

The following objectives have been the major concern in this study:

1. Collect and review existing literature on the impact of snowmelt on erosion.
2. Select suitable sites that would be representative of the winter wheat lands of Northwestern Colorado.
3. Collect new data on erosion from snowmelt on the selected sites.
4. Evaluate the factors used in the USLE to represent erosion from snowmelt.
5. Quantify the existing rill and ephemeral gully erosion on selected sites.
6. Make conclusions and recommendations for conservation treatment changes in the Field Office Technical Guide.

Other factors of interest which have not been studied include frost affects on erosion and the effects of rainfall events on ephemeral gullies. The personnel, equipment, and time limitations have not allowed these factors to be studied. Some selected excerpts from the proceedings of an international symposium on frozen soil impacts on agriculture lands have been included herein because of its significance to this study.

Authority

USDA participation in the cooperative river basin study is authorized under Section 6, Public Law 83-566, as amended. The sponsors of this particular study are the USDA Soil Conservation Service, Colorado State Soil Conservation Board, the Colorado First Soil Conservation District, and the Routt County Soil Conservation District.

Authorization for the study was based on a Plan of Work prepared in March, 1988. Authorization was later given to extend the study into the spring of 1990.

STUDY AREA

The study area includes selected non-irrigated cropland fields in Moffat and Routt Counties located within the Yampa River Basin in northwestern Colorado.

Nine fields, belonging to five land owners, were selected for data collection. The total number of acres involved varied from 686 acres in 1988 to 319 acres in 1989. The reason for the variation is movement of fields into the Conservation Reserve Program or crop rotation from wheat to stubble in summer fallow. Erosion rates were not measured on fields in stubble because there did not appear to be a significant erosion problem.

Climate

The study area includes fields at elevation 6400 ft in Moffat County near Craig, 6600 ft in Routt County near Hayden, and 6700 ft in Routt County near Steamboat Springs.

The average annual temperature at Craig is 42.3 degrees F with average monthly variations from 17.3 degrees in January to 66.9 degrees in July. The 32 degree frost free season is 96 days, 5 years out of 10. The average annual precipitation is 13.18 inches. The snow pack at the beginning of melt in early March had a water content of 2.5 inches in 1988, 5.0 inches in 1989, and 4.7 inches in 1990. These snow pack measurements were made at the fields studied near Craig.

The average annual temperature at Hayden is 42.0 degrees F with average monthly variations from 17.1 degrees in January to 66.2 degrees in July. The 32 degree frost free season is 91 days, 5 years out of 10. The average annual precipitation is 16.71 inches. The snow pack at the beginning of melt in early March had a water content of 12.4 inches in 1988, 10.4 inches in 1989, and 4.6 inches in 1990. These snow pack measurements were made at the fields studied near Hayden.

The average annual temperature at Steamboat Springs is 38.6 degrees F with average monthly variations from 14.8 degrees in January to 61.5 degrees in July. The 32 degree frost free season is 43 days, 5 years out of 10. The average annual precipitation is 23.94 inches. The snow pack at the beginning of melt in early March had a water content of 15.8 inches in 1988, 13.0 inches in 1989, and 5.9 inches in 1990. These snow pack measurements were made at the fields studied near Steamboat Springs.

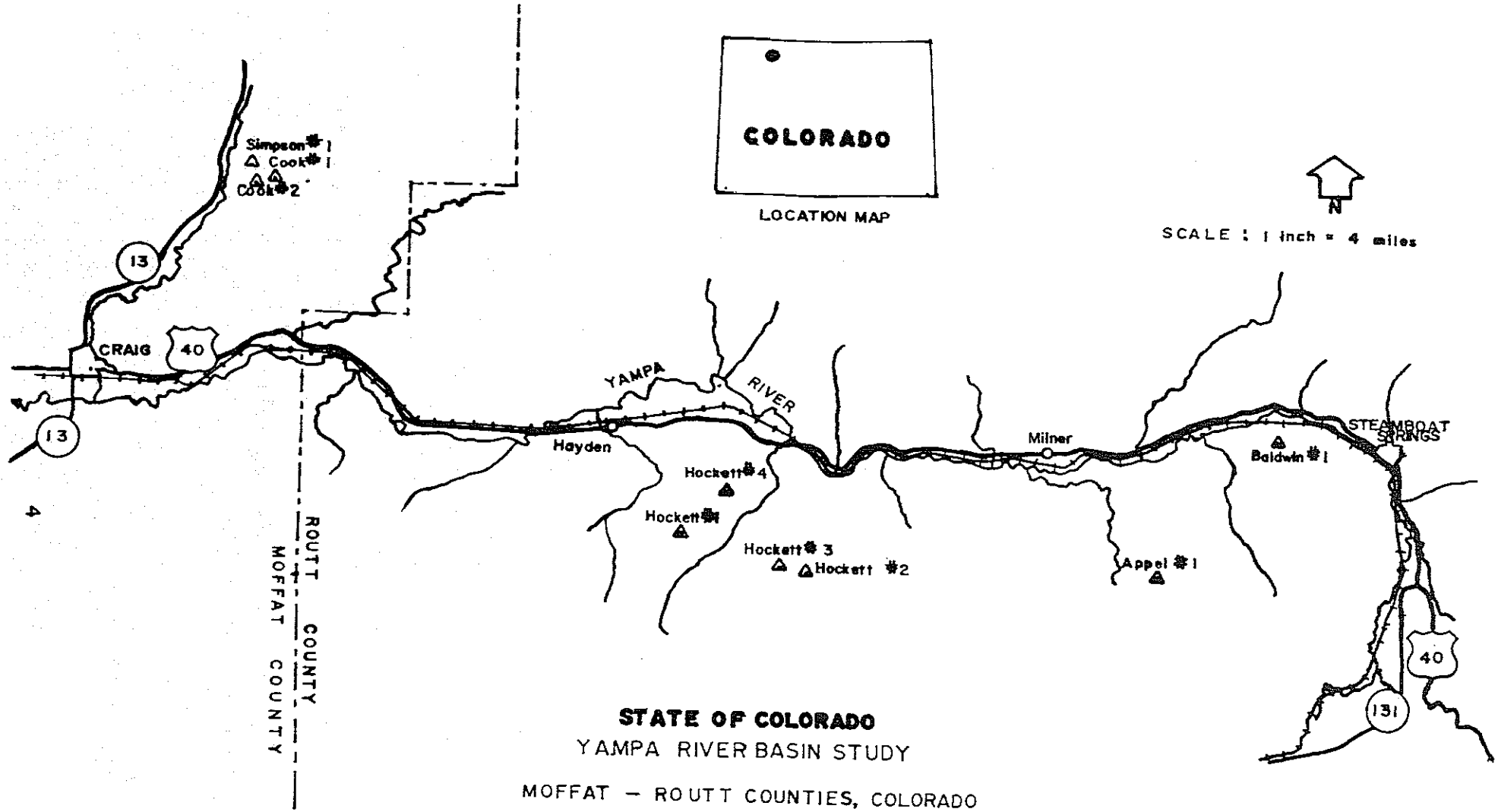
Field Characteristics

The fields studied are on rolling hills with slopes from 5% to 25%. The soil type for each field is shown in the following table;

Field	Soil Map Unit	Map Unit Name & Slope
	Moffat County	
Cook #1	64E	Forelle-Evanston Loam, 12-25%
	64D	Forelle-Evanston Loam, 1-12%
	33D	Pinelli Loam, 3-12%
Cook #2	64E	Forelle-Evanston Loam, 12-24%
	64D	Forelle-Evanston Loam, 1-12%
	218	Megonot Variant-Pinelli-Rock River Variant, 10-25%
Simpson #1	64E	Forelle-Evanston Loam, 12-25%
	64D	Forelle-Evanston Loam, 1-12%
	218	Megonot Variant-Pinelli-Rock River Variant, 10-25%
	Routt County	
Hockett #1	10C	Bulkley Silty Clay Loam, 3-12%
Hockett #2	4F	Abor Silty Clay, 25-65%
Hockett #3	10E	Bulkley Silty Clay Loam, 12-25%
Hockett #4	10E	Bulkley Silty Clay Loam, 12-25%
	10C	Bulkley Silty Clay Loam, 3-12%
	7C	Savage Loam, 3-12%
Appel #1	68C	Clayburn Loam, 3-12%
	50C	Chocetopa Loam, 3-12%
	2C	Buckskin Loam, 3-12%
Baldwin #1	50E	Chochetopa Loam, 12-25%

The crop rotation generally includes winter wheat to fallow to winter wheat in alternate years. The farming operations generally include several operations of disking, chiseling, or sweeping from May through August. Seeding is done in Sept-Oct and harvesting in Aug. At the time of seeding, and the following spring during snowmelt, there is little residue present. Occasionally additional seeding is done in the spring on sites with a poor stand of wheat.

Ephemeral gullies and rills are generally filled in during the summer farming operations.



STATE OF COLORADO

YAMPA RIVER BASIN STUDY

MOFFAT – ROUTT COUNTIES, COLORADO

FIGURE 1

LOCATION MAP OF SELECTED FIELDS △

INVESTIGATIONS AND ANALYSIS

Snowmelt Considerations

Snow depth and water content were measured in March of 1988, 1989,and 1990 at three general locations. These locations are in the vicinity of Craig, Hayden, and Steamboat Springs and are considered representative of fields selected for rill and ephemeral gully erosion study. The snow water content were as follows:

	Mar 1988	Mar 1989	Mar 1990
Craig	2.5 in	5.0 in	4.7 in
Hayden	12.4 in	10.4 in	4.6 in
Steamboat Spr	15.8 in	13.0 in	5.9 in

Snowmelt rates are determined using mean daily temperatures during the melt period of Mar. 15 to Apr. 15. Daily temperature data was obtained for the melt season of 1988 and 1989. This data, along with snowpack data, were used in the degree-day snowmelt equation to determine daily melt rates. The following data reflects the magnitude of maximum and average daily snowmelt rates:

1988 -

Craig max = 0.83 in/day
avg = 0.47 in/day

Hayden max = 1.38 in/day
avg = 0.55 in/day

Steamboat Spr max = 1.23 in/day
avg = 0.59 in/day

1989 -

Craig max = 0.89 in/day
avg = 0.49 in/day

Hayden max = 1.14 in/day
avg = 0.53 in/day

Steamboat Spr max = 1.26 in/day
avg = 0.49 in/day

1990 -

Not determined.

Frost Considerations

The following are excerpts taken from an international symposium proceedings titled "Frozen Soil Impacts on

Agricultural, Range, and Forest Lands", March 21-22, 1990 at Spokane Washington.

(Ref 8) - "Freeze Thaw Effects on Soil Strength" by Hans Kok and Donald K. McCool

Soils accumulate moisture prior to the freezing cycles and often freeze wet with resultant low infiltration capacities.

More than 50 percent of the soil erosion in the Palouse region is related to rain or snowmelt on frozen or thawing ground.

Soil strength upon thawing would often be 50 percent or less of the pre-freeze strength. Sunny conditions caused rapid thaw of the top several millimeters of the soil profile while the underlaying layers were still frozen. The super-saturated top layer would flow down the hill indicating a near absence of soil strength.

A slight consolidation and strengthening of the soil after fall tillage and a slight strengthening trend in the spring as the soil dried were observed.

(Ref 9) - "Influence of Management Practices on Snowmelt Runoff" by D.S. Chanasyk and C.P. Woytowich

Willis and Haas (1969) found if snow was held where it fell and if the soil was dry in the fall before freezing, spring runoff amounted to approximately 50% of the snowpack; if the soil was wet before freezing, approximately 80% ran off.

(Ref 10)- "Crop Management Effects on Runoff and Soil Loss From Thawing Soil" by Donald K. McCool.

Crop management can have a major impact on both runoff and erosion for events when there is no frozen soil or if the soil is only frozen to a shallow depth and thaws rapidly.

Crop management can have a major impact on erosion for events when the soil is deeply and impermeably frozen.

It appears that the frost impacts in Colorado include freezing of the soil profile, then an initial thawing of the top inch or so during snowmelt. Sufficient deeper frost prevents infiltration and promotes runoff. The degree of

mpact varies from year to year depending on the soil moisture level, the amount of snow pack, and temperatures.

Rill Erosion Evaluations

Selected fields were used to quantify rill erosion occurring in winter wheat fields in the study area. Transects were taken in sample areas and the Alutin Rill Erosion Method was used to determine erosion rates. The transects were needed to determine the range in magnitude of existing erosion. With this range in mind, 4 rate categories were assigned:

High = 37 Ton/Ac
Medium = 17 Ton/Ac
Low = 6 Ton/Ac
Minor = 1 Ton/Ac

The selected fields were inspected and mapped showing erosion rate categories. The acres by rate category were weighted to give an average rill erosion rate by field and for all fields. This was done for the spring of 1988, 1989, and 1990.

1988 -
Field acres = 686.8 ac
Percent of High = 8.0
Medium = 21.0
Low = 61.0
Minor = 10.0
Avg rill erosion rate = 10.37 ton/ac

1989 -
Field acres = 319.0 ac
Percent of High = 7.0
Medium = 12.0
Low = 52.0
Minor = 29.0
Avg rill erosion rate = 8.08 ton/ac

1990 -
Field acres = 524.4 ac
Percent of High = 2.0
Medium = 5.0
Low = 18.0
Minor = 75.0
Avg rill erosion rate = 3.28 ton/ac

Tables 1a, 1b, and 1c show data for individual fields.

The above data pertains to rill erosion from snowmelt and should be included with rates determined for the summer and all seasons when annual values are desired.

The erosion rates determined with transect measurements show rates as high as 80 tons per acre. These areas are usually quite small in size with averages for a field much lower.

The USLE equation is the current method for estimating rill erosion. The USLE equation can now be solved on personal computers using the program RUSLE. An attempt was made in this study to measure rill erosion in the field and compute the R-value from the USLE equation;

$$A=RK(LS)CP$$

A= Soil loss (Tons/Acre/Year)
R= Rainfall and runoff factor
K= Soil erodibility factor
LS= Length and percent slope factor
C= Cover and management factor
P= Erosion control practice factor

The following factors were held constant for all fields involved in the study;

(1) Cover and management factor C=0.42
(2) Erosion control practice factor P=1.0
(3) Slope lengths measured in the field varied from 300 ft to 450 ft with an average of 375 ft.

Therefore the rearranged USLE equation is;

$$R=A/0.42*K*(LS)$$

(LS) is selected from a table using L=375 ft

Rill erosion for the summer rain season was projected using an erosion index distribution curve from Colorado Technical Note 50 (1984). This value was added to the measured erosion on each field for the spring snowmelt period and an R-value was computed using the total annual rill erosion.

The following table shows the remaining factors A, K, (LS) and the computed R-value for each field measured.

Field	K	LS	Ar	1988		1989		1990	
				As	R	As	R	As	R
COOK 1	0.26	1.6	3.0	----	----	5.5	49.1	----	----
COOK 2	0.26	2.3	4.4	13.3	69.5	----	----	3.4	30.6
SIMP 1	0.32	3.4	7.8	8.0	34.8	----	----	1.4	20.3
HOCK 1	0.31	3.4	7.6	8.9	37.4	----	----	9.3	38.4
HOCK 2	0.31	6.1	13.6	11.5	31.8	----	----	6.1	25.0
HOCK 3	0.31	7.3	16.3	27.5	46.4	----	----	----	----
HOCK 4	0.31	2.3	5.2	----	----	18.2	77.2	----	----
APEL 1	0.20	3.4	4.9	----	----	5.4	36.2	----	----
BALD 1	0.24	1.4	2.3	6.6	65.7	----	----	----	----
AVG					47.6		54.2		28.6

Note:Ar is USLE computed erosion for the summer rain season
As is the field measured erosion from snowmelt

The R-value averaged 43.3 for the 3 year study period. The rill erosion rate for the spring of 1990 was very low compared to 1988 and 1989 and had a significant weighting affect on the 3 year average.

The standard book R-value is computed from the equation;

$$R=27.38*(P2yr)^{2.17}$$

P2yr is the 2 year freq, 24 hr precip

The general value of P2yr for the study area varies from 0.85 to 0.90 inches with a typical average of 0.88 inches. Therefore the R-value, by the book, is 20.75.

A possible alternative in estimating the snowmelt component of rill erosion involves snowmelt rates or mean daily temperatures that affect snowmelt rates.

Until further research improves the USLE equation to account more fully for snowmelt erosion, the adoption of an appropriate R value is needed.

D.K. McCool, a research agricultural engineer with USDA-ARS, Pullman Washington, has developed an equation to compute an equivalent R value for regions susceptible to frozen soils and erosion from winter precipitation. The possibility of using his equation for parts of Colorado should be pursued.

TABLE 1a

RILL EROSION DATA FOR SNOWMELT DATE: 1988

MAPPED RATES - TON/AC AVG RILL EROSION RATE = 10.37 TON/AC

HIGH	=	37
MEDIUM	=	17
LOW	=	6
MINOR	=	1

FIELD ID	FIELD AC	SOIL	MAPPED RATES - AC HIGH	MED	LOW	MINOR	WEIGHTED AVG T/A	TRANSECT SITE ID		TRANSECT EROS T/A
COOK 2	176.0	L	27.0	45.0	94.0	10.0	13.28	WEST	1	37.36
								MIDDLE	2	16.65
								EAST	3	3.79
SIMP 1	259.0	L/SL	5.0	44.0	185.0	25.0	7.98		1	4.81
HOCK 1	51.1	SCL	3.6	7.0	32.5	8.0	8.91		1	36.41
HOCK 2	120.7	SC	8.7	38.8	65.4	7.8	11.45		1	11.65
HOCK 3	16.9	SCL	11.7	0.0	5.2	0.0	27.46		1	35.19
BALD 1	63.1	L	0.0	10.0	38.6	14.5	6.59		1	14.56
	686.8		56.0	144.8	420.7	65.3				

TABLE 1b

RILL EROSION DATA FOR SNOWMELT DATE: 1989

MAPPED RATES - TON/AC AVG RILL EROSION RATE = 8.08 TON/AC

HIGH	=	37
MEDIUM	=	17
LOW	=	6
MINOR	=	1

FIELD ID	FIELD AC	SOIL	MAPPED RATES - AC HIGH	MED	LOW	MINOR	WEIGHTED AVG T/A	TRANSECT SITE ID	TRANSECT EROS T/A
COOK 1	193.0	L	0.0	30.0	78.0	85.0	5.51	1	27.21
								2	21.60
HOCK 4	65.0	SCL	22.0	10.0	33.0	0.0	18.18	1	83.59
								2	17.27
APEL 1	61.0	L	0.0	0.0	54.0	7.0	5.43	1	14.20
								2	5.5
								3	7.5
								4	4.67
	319.0		22.0	40.0	165.0	92.0			

TABLE 1c

RILL EROSION DATA FOR SNOWMELT DATE: 1990

MAPPED RATES - TON/AC AVG RILL EROSION RATE = 3.28 TON/AC

HIGH	=	37
MEDIUM	=	17
LOW	=	6
MINOR	=	1

FIELD ID	FIELD AC	SOIL	MAPPED RATES - AC HIGH	MED	LOW	MINOR	WEIGHTED AVG T/A	TRANSECT SITE ID	TRANSECT EROS T/A
COOK 2	176.0	L	2.6	11.2	28.5	133.7	3.36	1	69.03
								2	25.79
SIMP 1	219.6	L/SL	0.0	1.0	16.0	202.6	1.44	1	11.15
HOCK 1	8.1	SCL	1.0	1.0	3.0	3.1	9.27	1	55.28
HOCK 2	120.7	SC	4.8	12.3	49.5	54.1	6.11	1	10.48
								2	30.99
	524.4		8.4	25.5	97.0	393.5			

Note: 39.4 Ac of Simp Field #1 & 43.0 Ac of Hock Field #1
were in stubble or CRP and not mapped in 1990

Ephemeral Gully Evaluations

Selected fields were used to quantify ephemeral gully erosion occurring on winter wheat fields in the study area. Sample areas in these fields were selected for measurement. The tons of erosion per 1000 ft of ephemeral gully on the sample areas was applied to the total length of gullies in the entire field. The total length of gullies on the entire field was determined from field inspection. Each existing gully was plotted on a map and lengths were measured in the office. This process was followed for the spring of 1988, 1989, and 1990. A summary of this analysis is as follows:

1988 -
Field acres = 686.8 ac
Total field gully length = 32909 ft
Total field gully erosion = 1435.8 tons
Field gully erosion rate = 2.09 ton/ac

1989 -
Field acres = 319.0 ac
Total field gully length = 12500 ft
Total field gully erosion = 328.6 tons
Field gully erosion rate = 1.03 ton/ac

1990 -
Field acres = 524.4 ac
Total field gully length = 28080 ft
Total field gully erosion = 1275.4 tons
Field gully erosion rate = 2.43 ton/ac

Tables 2a, 2b, and 2c show data for individual fields.

These erosion rates are significant and should be considered as part of the overall erosion problem.

The Ephemeral Gully Erosion Model (EGEM) is the current method for evaluating ephemeral gully erosion. It is also considered a tool to study affects of different land treatment changes on the development of ephemeral gullies.

The EGEM Model is intended to predict erosion rates for a given drainage basin with specified physical characteristics and a given single storm event or for an average annual value. The single storm event is more appropriate for this study. A method was needed therefore to represent the snowmelt effects as a single storm event. A reference to the model documentation provided a way to do this. The reference stated "a gully volume is voided only once a year due to a maximum runoff event. Later events will not cause further erosion in the gully and earlier events will not create the maximum voided area". Therefore the maximum snowmelt day would create the gully measured in the field.

TABLE 2a
EPHEMERAL GULLY EROSION - 1988

NOTE: FLD GUL LENGTH MEASURED FROM FIELD MAPING
FLD GUL EROS = BASIN GUL EROS*FLD GUL LENGTH

BASIN GUL EROSION RATE = 3.77 TON/AC
FIELD GUL EROSION RATE = 2.09 TON/AC

FIELD ID	FIELD AC	BAS GUL AC	BAS GUL LENGTH FT	BAS GUL EROS T/1000 FT	FLD GUL LENGTH FT	FLD GUL EROS TONS
HOCK 1	51.1	0	0	52.56	1914	100.6
HOCK 2	120.7	15.1	2096	28.81	5400	155.6
HOCK 3	16.9	7.2	880	55.96	1000	56.0
BALD 1	63.1	7.3	890	25.26	4195	106.0
COOK 2	176.0	29.0	1550	60.08	11000	660.9
SIMP 1	259.0	5.5	431	37.96	9400	356.8
TOTAL	686.8	64.1	5847	41.32	32909	1435.8

TABLE 2b
EPHEMERAL GULLY EROSION - 1989

NOTE: FLD GUL LENGTH MEASURED FROM FIELD MAPING
FLD GUL EROS = BASIN GUL EROS*FLD GUL LENGTH

BASIN GUL EROSION RATE = 2.21 TON/AC
FIELD GUL EROSION RATE = 1.03 TON/AC

FIELD ID	FIELD AC	BAS GUL AC	BAS GUL LENGTH FT	BAS GUL EROS T/1000 FT	FLD GUL LENGTH FT	FLD GUL EROS TONS
HOCK 4	65.0	4.65	476	45.52	2300	104.7
APEL 1	61.0	13.12	1197	39.97	2900	115.9
COOK 1	193.0	23.82	1526	14.79	7300	108.0
TOTAL	319.0	41.59	3199	28.78	12500	328.6

TABLE 2c
EPHEMERAL GULLY EROSION - 1990

NOTE: FLD GUL LENGTH MEASURED FROM FIELD MAPING
FLD GUL EROS = BASIN GUL EROS*FLD GUL LENGTH

BASIN GUL EROSION RATE = 3.42 TON/AC
FIELD GUL EROSION RATE = 2.43 TON/AC

FIELD ID	FIELD AC	BAS GUL AC	BAS GUL LENGTH FT	BAS GUL EROS T/1000 FT	FLD GUL LENGTH FT	FLD GUL EROS TONS
HOCK 1	8.1	0.0	0	52.56	180	9.5
HOCK 2	120.7	15.1	2096	28.81	9300	267.9
COOK 2	176.0	29.0	1550	60.08	13200	793.1
SIMP 1	219.6	5.5	431	37.96	5400	205.0
TOTAL	524.4	49.6	4077	41.67	28080	1275.4

Note: Previously developed basin gully erosion rates were applied to 1990 field measured gully lengths. A 1990 field check showed 67.5 T/1000 Ft on one gully system in Cook Field #2.

A number of ephemeral gullies measured in this study were used to test the operation of the EGEM. As expected with most computer models, some measured gullies matched quite well with the model and others did not. Usually a match could be made by varying the channel erodibility coefficient (KCH) or the critical shear coefficient (CS). The main problem with the model is the lack of detailed reliable KCH and CS coefficients for existing field conditions. As more detailed data becomes available the model should be quite useful in predicting eqhemeral gully erosion.

Economics of Erosion

The interrelationship between topsoil, organic matter, and erosion is one of the most complex and dynamic topics in the resource field.

There are numerous references dealing with the subject therefore it is sufficient in this report to list a few that may be researched, and not attempt to review the subject in detail.

The following references should be of interest on the subject;

(Ref 11) - "Assessing Soil Erosion Productivity Damage" by Douglas L. Young and David J. Walker

Reparable damage is usually associated with loss of soil fertility from erosion and is that portion of the yield decline from erosion that can be restored by increasing organic matter, fertilizer, or other inputs. After economically optimal input adjustments, there will usually be residual yield damage due to deterioration in the soil environment. Reduced moisture infiltration and retention capacity, diminished rooting zone, and impaired soil structure cause residual damage to yields that cannot be remedied economically.

(Ref 12) - " Developing a Soil Loss Damage Function: Does Erosion Pay?" by David J. Walker

Even before erosion reaches the point where the topsoil has been stripped from a field, the cumulative effect of erosion is evident in reduced crop yield. The reduced yields are partly due to the loss of essential nutrients. The selective erosion of nutrients and organic matter means poorer quality crops and lower yields. As erosion exposes the subsoil to

cultivation, yields decrease for another reason. The subsoil generally has a more blocky structure than topsoil and produces a rougher seedbed to the detriment of germination and yields.

(Ref 13) - " A Suggested System Simulation Approach for Evaluating the Long-Run Economic Return and the Adoption Potential for Soil-Conserving Tillage Systems" by Douglas L. Young

In popular terminology, the farmer who fails to protect his topsoil in the near term is opening himself to a potential "double Punch" in the future. First, he reduces future yields directly because shallower soils produce lower yields. Second, and equally important, he reduces future potential compensating yield boosts on his land from improvements in agricultural technology, because these improvements have a lower payoff on shallower topsoils. Today we may be entering an era where this double punch will have greater force because direct and indirect effects of erosion grow more severe as topsoil grows shallower after several years of erosive farming practices.

TREATMENT OPPORTUNITIES

Minimum Tillage

Rill and ephemeral gully erosion is caused by runoff from snowmelt in the spring and from summer rains.

Research has shown that management practices, such as minimum tillage and the retention of residue, can reduce runoff from summer rains. This is best illustrated by referring to the Soil Conservation Service "Engineering Field Manual - Chapter 2 - Estimating Runoff and Peak Discharges". The hydrologic soil-cover-complex (CN) is an index number that reflects the potential of a given field to produce runoff from a rainfall event. The higher the index number the greater the runoff. A typical field in fallow condition with no significant residue has a CN of 91 and would produce 1.16 inches of runoff from a 2.0 inch rain. The same field with good crop residue would have a CN of 88 and produce 0.97 inches of runoff from a 2.0 inch rain. This is a 16% reduction in runoff. A similar impact of residue can be shown on a field planted to winter wheat.

Research has shown that residue cover has an insulating affect on the freezing of soils. An additional factor is the fact that residue traps winter snow which also insulates the soil. Frozen soils in the spring can promote higher runoff from snowmelt than if the soil is not frozen, because of differences in the infiltration rate.

Farming Operations

Observations made during this study showed farming up and down the slopes enhanced rill and ephemeral gully erosion. Across slope farming increases the roughness factor and detention storage of a field which improves infiltration.

Some research has shown that runoff can be reduced by cultivation. Farmers who cultivate fields in the fall may increase their soil water content, although the increase would not likely be large.

As discussed earlier, hydrologic curve numbers (CN) are affected by the presence of residue. Farming operations can also affect the CN. A typical winter wheat field seeded in straight rows would have a CN of 83, however if the field were seeded on the contour, the CN would be 81. The use of terraces would have an additional affect on reducing the CN to 78.

Other

There have been some fields included in this study that have been converted from winter wheat to permanent grasses or alfalfa as a part of the conservation reserve program. This has come about during the 3 year study period.

Continuing the reference to hydrologic curve numbers (CN), a typical field planted to winter wheat may have a CN of 83, however if the field were in grass pasture or range, the CN would be 79. This implies that less runoff as well as less erosion would occur from a field in grass than one in winter wheat or fallow.

CONCLUSIONS AND RECOMMENDATIONS

It was apparent, from our field work, that fallowed fields with significant amounts of stubble produce minor amounts of rill and ephemeral gully erosion from snowmelt. It was also apparent that the direction of drilling, down slope vs across slope, had an affect on the occurrence of rills. Across slope drilling seems to reduce rilling.

A number of photographs with associated erosion rates are included herein for reference purposes. They should be of value when erosion rate estimates are needed for future conservation planning.

The spring snowmelt seasons of 1988, 1989, and 1990 were the time periods used in collecting data for this study. Average field rill erosion rates were 10.37 ton/ac for the 1988 period, 8.08 ton/ac for 1989 and 3.28 ton/ac for 1990. Ephemeral gully erosion rates were 2.09 ton/ac in 1988, 1.03 ton/ac in 1989, and 2.43 ton/ac in 1990.

Frost data has not been available therefore its affect can not be determined. Other studies have shown that freeze-thaw cycles do reduce the shear strength of soils considerably which would increase its susceptibility to erosion. The presence of frost during the snowmelt period enhances runoff rather than infiltration. It was an observation by study participants that the soils appeared less consolidated or more erosive in the spring of 1988 compared to 1989.

Snow water content and mean daily temperatures during March and early April have a bearing on melt rates. High melt rates are more likely to produce rill and ephemeral gully erosion.

Land treatment differences were not significant between the years studied. The fields measured for erosion were fall planted to winter wheat and growth at the time of measurement was almost insignificant. Little residue was present on the fields studied.

Table 3 shows the results of an EGEM analysis of a sample hydrologic basin within a selected field. The data shows a wheat field with no significant residue planted in straight rows would produce 1.4 tons of ephemeral gully erosion per acre. If farming practices were changed to make use of crop residue on at least 20% of the surface area, and planted on the contour, the ephemeral gully erosion would be eliminated.

Since there is insufficient data at this time to relate snowmelt erosion rates to specific factors, it is recommended that rates shown herein be used as a reference to estimate values for future planning. Further studies may identify specific relationships between erosion rates, mean daily temperatures, snowmelt rates, or other factors. The Donald K. McCool equation for computing R values in the USLE should be considered for this part of Colorado because of the impact of frost and snowmelt on erosion rates.

A new model (WEPP) , which will replace the USLE, and include EGEM, for predicting erosion is in the development stages. It will eventually include provisions to analyze erosion from snowmelt.

TABLE 3

EPHEMERAL GULLY DATA FOR SAMPLE BASIN

NON-VARIABLE INPUT DATA

Dr Area=	3.16 Ac	Soil=	Loam
Basin S=	7.8 %	Gully S=	8.4 %
Gully L=	261 Ft	Gully D=	3.5 In
Precip =	1.18 In		

Variable	Units	Str Row	Str Row + Crp Res	Cont	Cont + Crp Res	Remarks
KCH		0.250	0.028	0.250	0.028	Chan Erod Fac
CS		0.028	0.220	0.028	0.220	Crit Shear
Curv Num		76	72	74	72	
Runoff	In	0.08	0.03	0.06	0.03	
Peak	cfs	0.2	Trace	0.1	Trace	
Gull Wid	Ft	2.0	0	1.4	0	
Tot Eros	Ton	4.3	0	3.1	0	
Eros Rate	Ton/Ac	1.4	0	1.0	0	

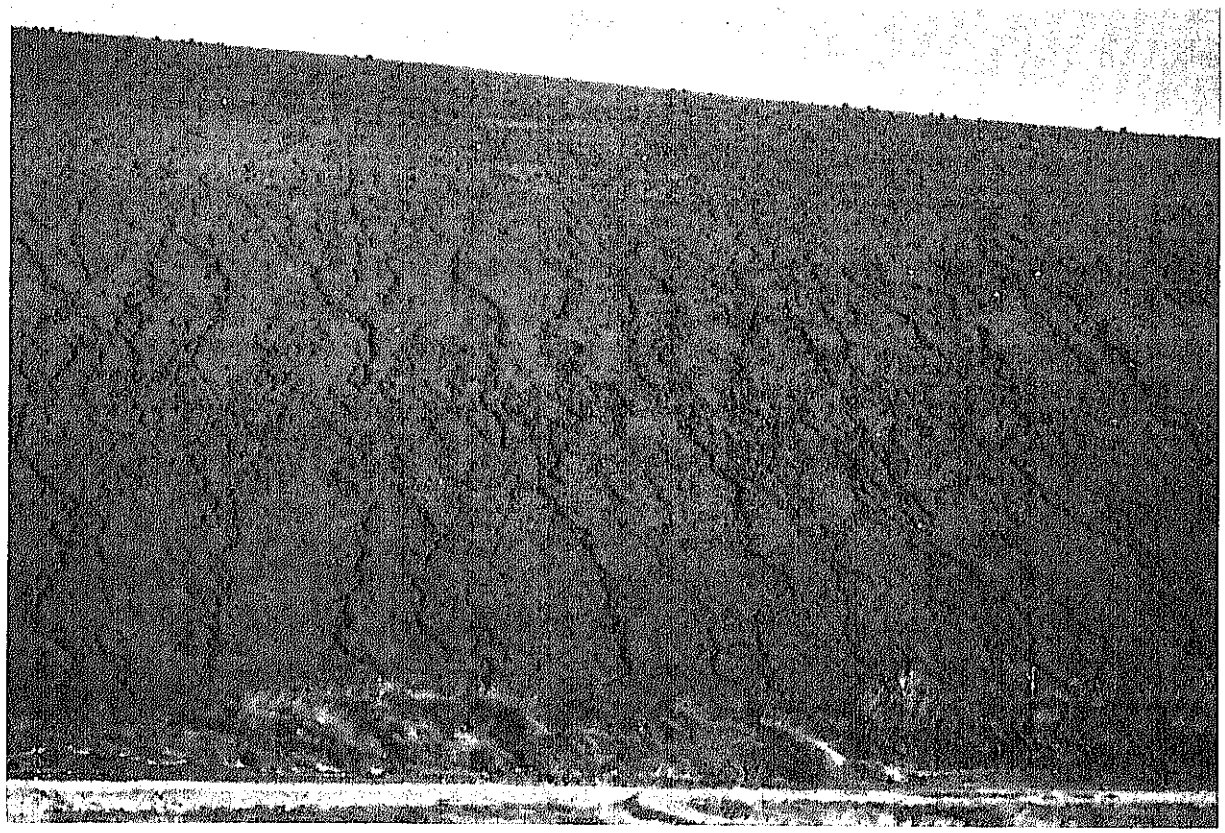
Note: Cont - planted on the contour
Str Row - planted in straight rows not on a contour
Crp Res - at least 20% of ground has crop residue

REFERENCES

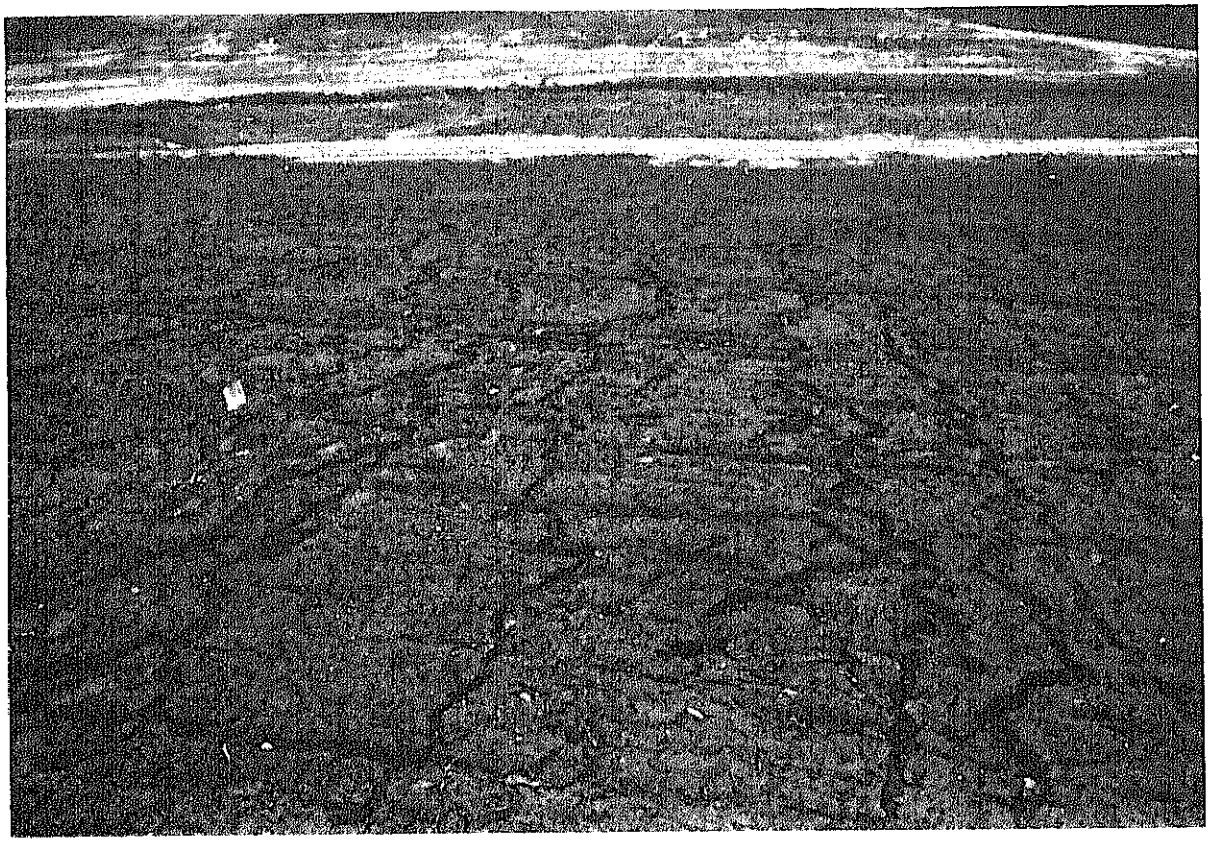
(1) Field Office Technical Guide (FOTG) Section IC - Erosion Prediction
(2) Colorado Technical Note #50 - Guide for Predicting Soil Loss from Water Erosion
(3) Colorado Technical Note #53 - Colo. Wind Erosion Guide
(4) National Engineer Bulletin #210-4-6 (12/7/83) Eng - Ephemeral Cropland Gully Erosion
(5) Agronomy Handbook #65 - Estimating Gross Rill Erosion in tons per acre (7/83) (Alutin Rill Erosion Method)
(6) Agronomy Handbook #67 - SCS Procedure for Estimating Gross Erosion (10/83)
(7) Agronomy Handbook #537 - Predicting Rainfall Erosion Losses (USLE)
(8) Freeze Thaw Effects on Soil Strength, by Hans Kok and Donald K. McCool
(9) Influence of Management Practices on Snowmelt Runoff by D.S. Chanasyk and C.P. Woytowich
(10) Crop Management Effects on Runoff and Soil Loss From Thawing Soil by Donald K. McCool
(11) Assessing Soil Erosion Productivity Damage by Douglas L. Young and David J. Walker
(12) Developing a Soil Loss Damage Function: Does Erosion Pay? by David J. Walker
(13) A Suggested System Simulation Approach for Evaluating the Long-Run Economic Return and the Adoption Potential for Soil-Conserving Tillage Systems by Douglas L. Young

CREDITS

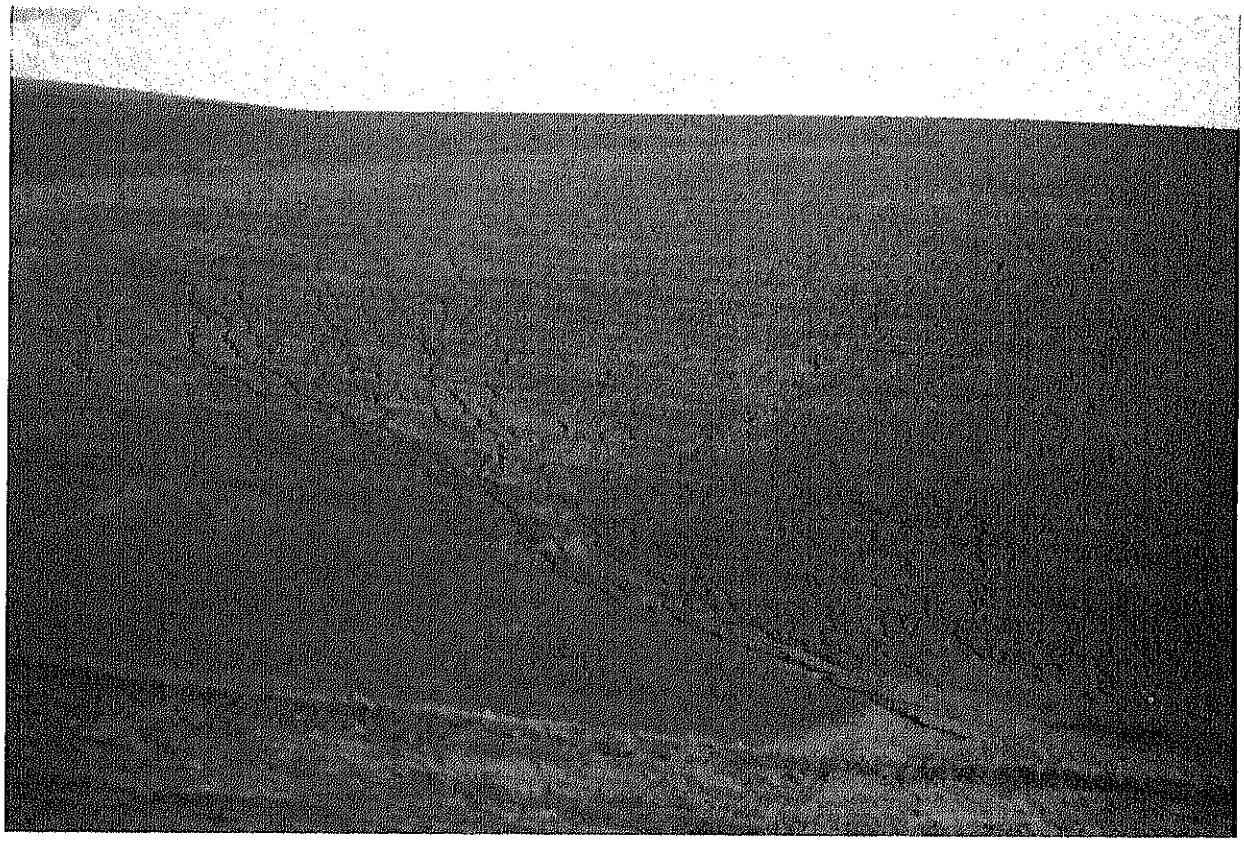
Photography by Gene Alexander and Glade Wilkes



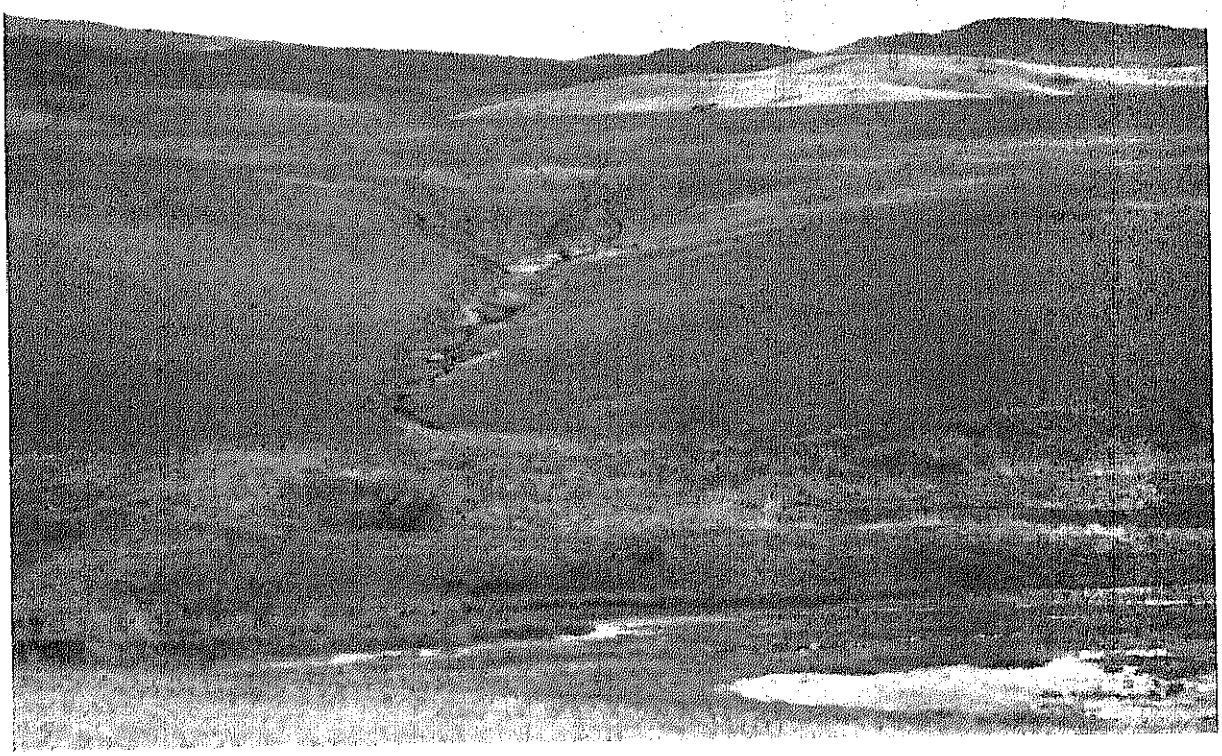
35 Ton/Ac (Measured) rill erosion



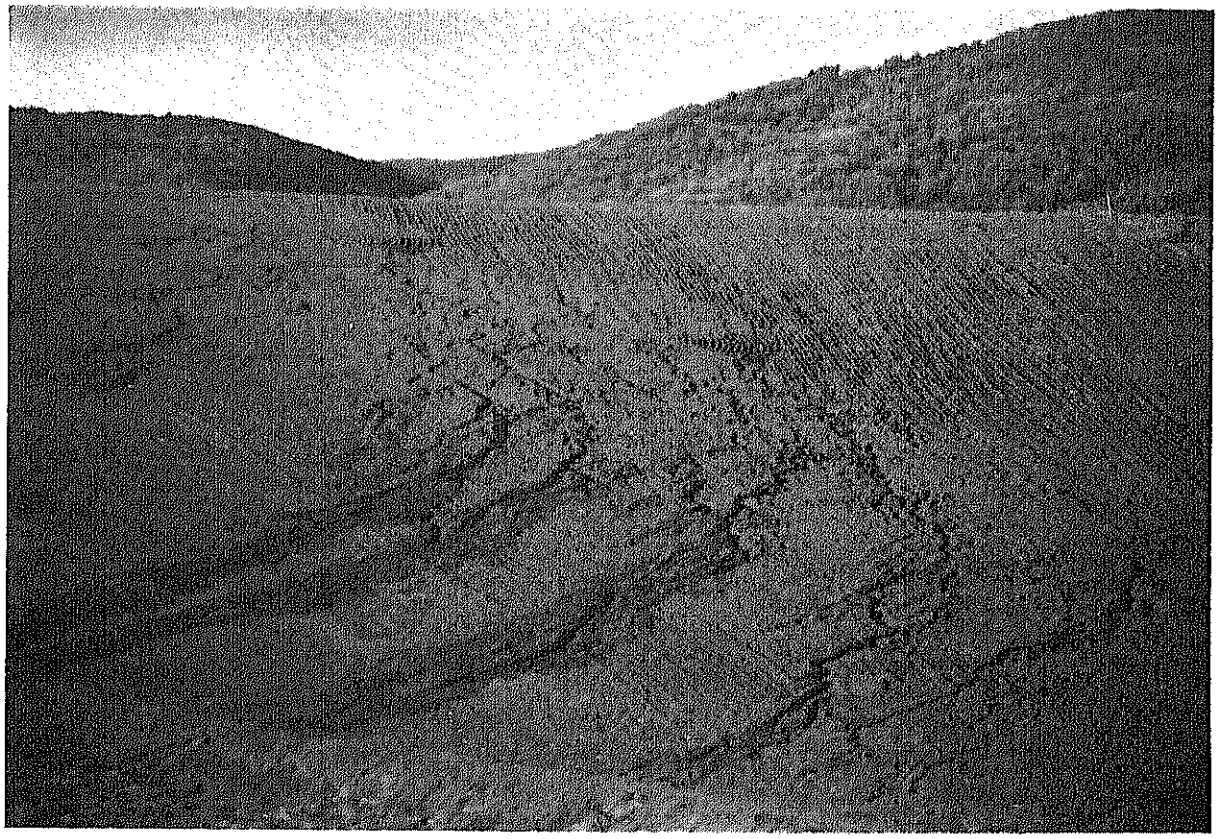
35 Ton/Ac (Measured) rill erosion



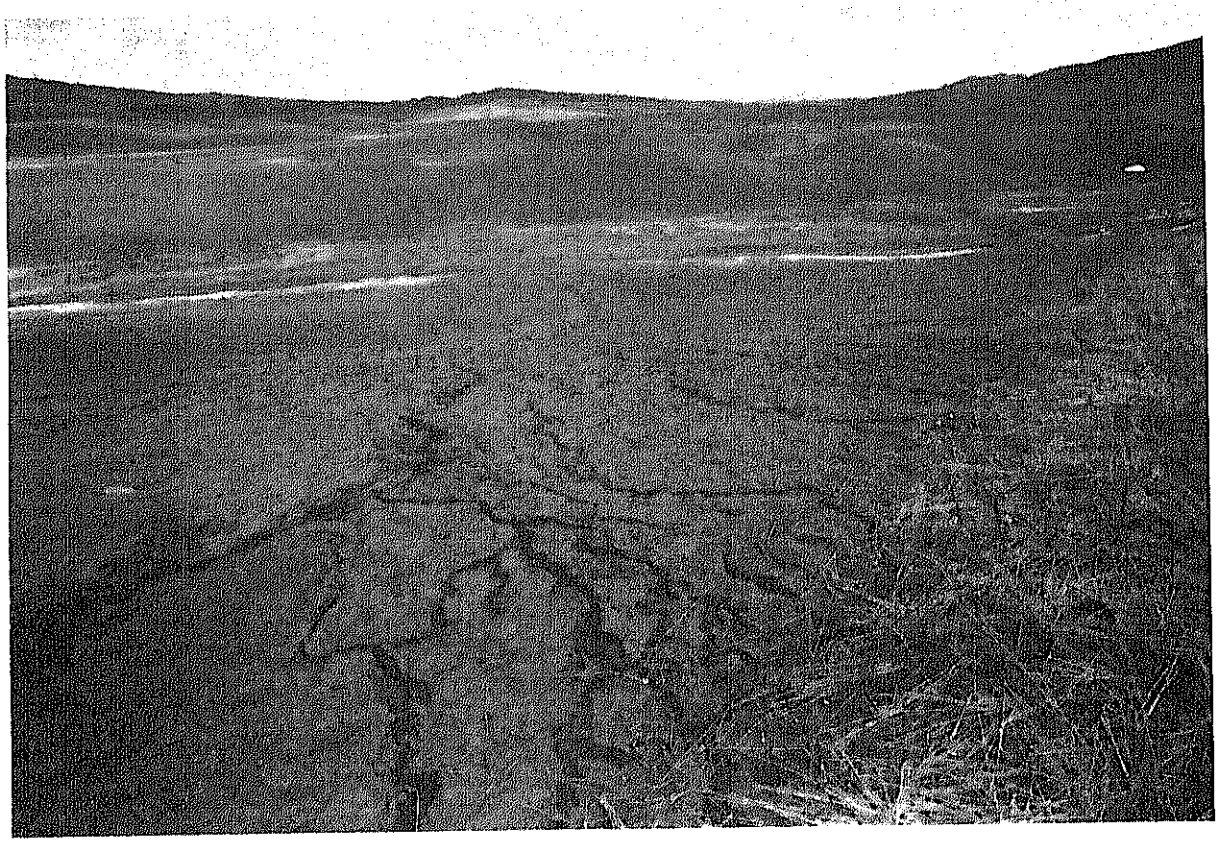
Typical rill erosion



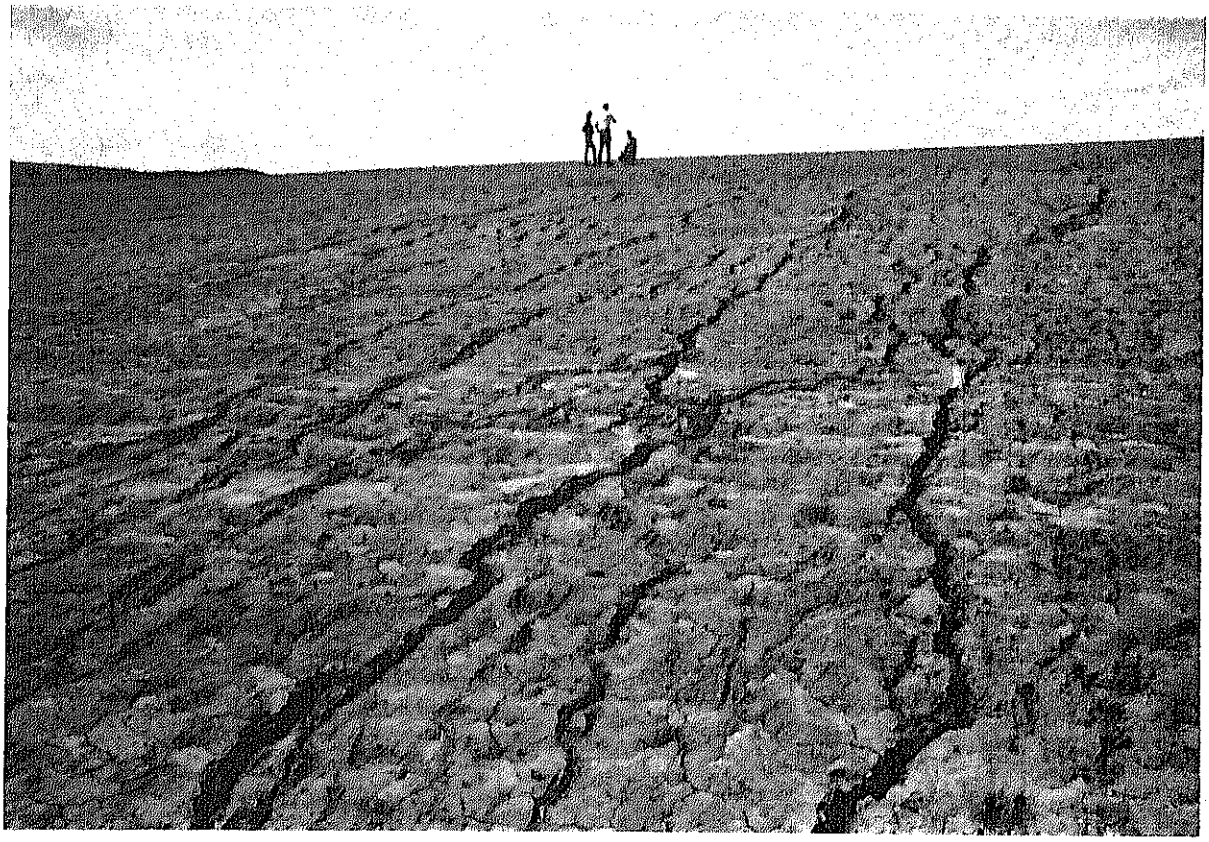
Typical ephemeral gully system



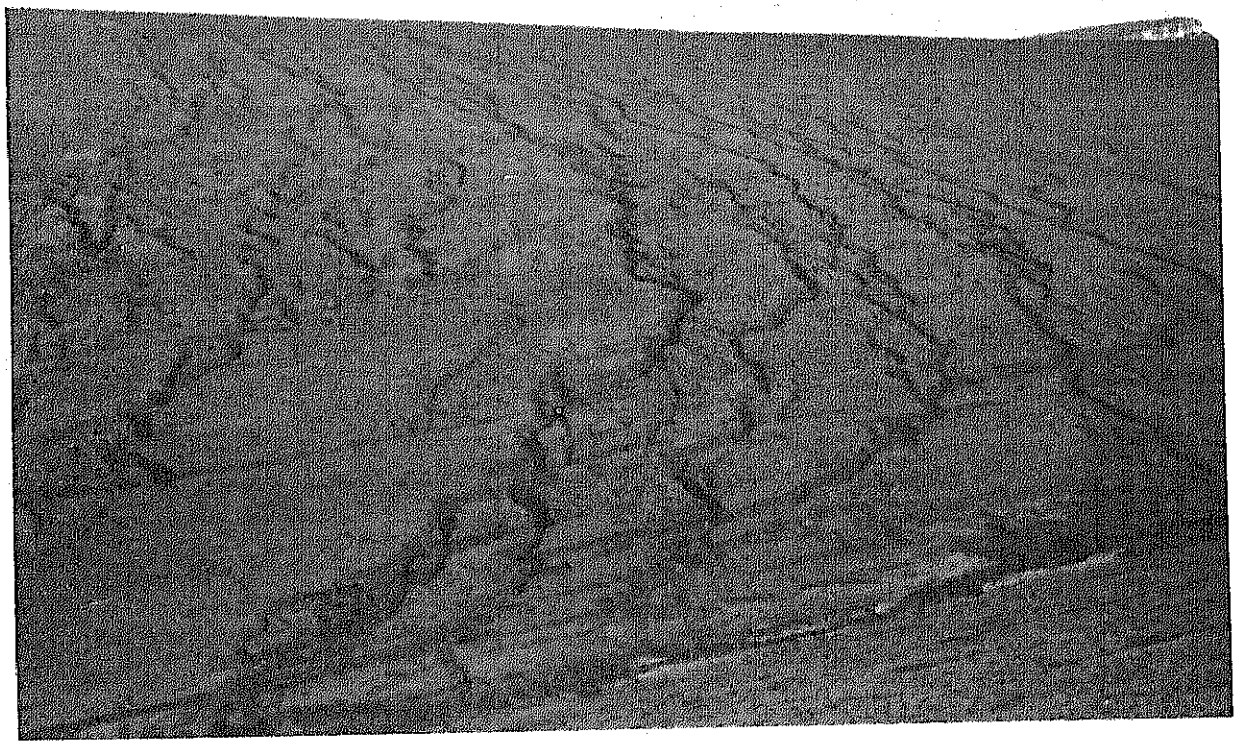
The affect of drill rows on
rill erosion



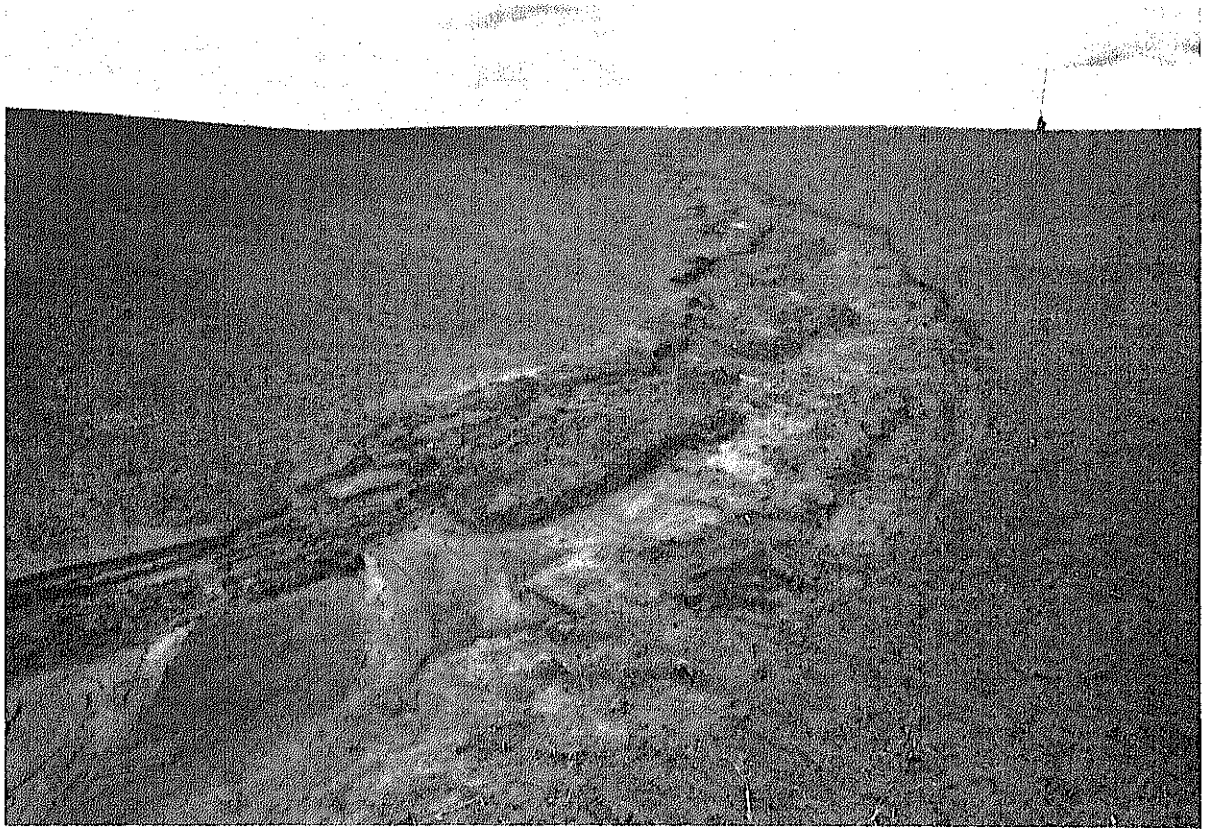
No significant erosion occurred in the stubble field, however rilling began at the edge of the planted wheat field.



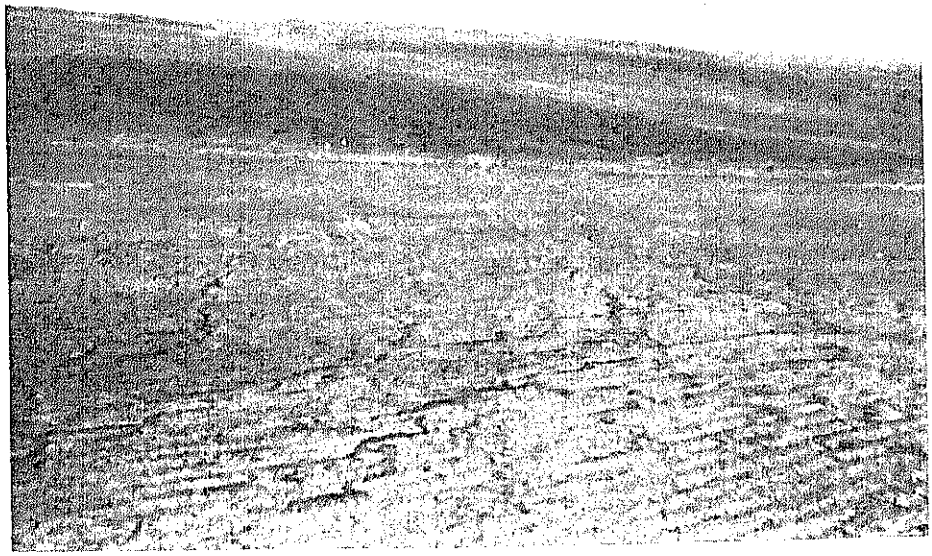
14 Ton/Ac (Measured) rill erosion



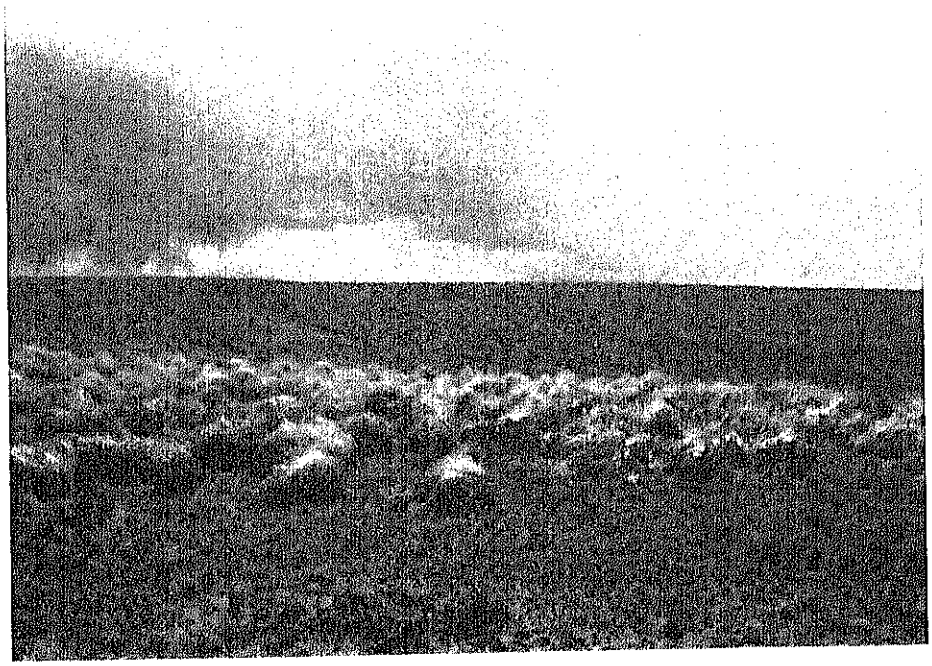
40 Ton/Ac (Measured) rill erosion



Ephemeral gully from 7.2 acre
watershed - 6.8 Tons/Ac



11.2 Ton/Ac (Measured) Rill Erosion



Grass filter strips that intercepts
sediment from 69 Ton/Ac rill erosion

*U.S. GOVERNMENT PRINTING OFFICE: 1990--776-132/25140